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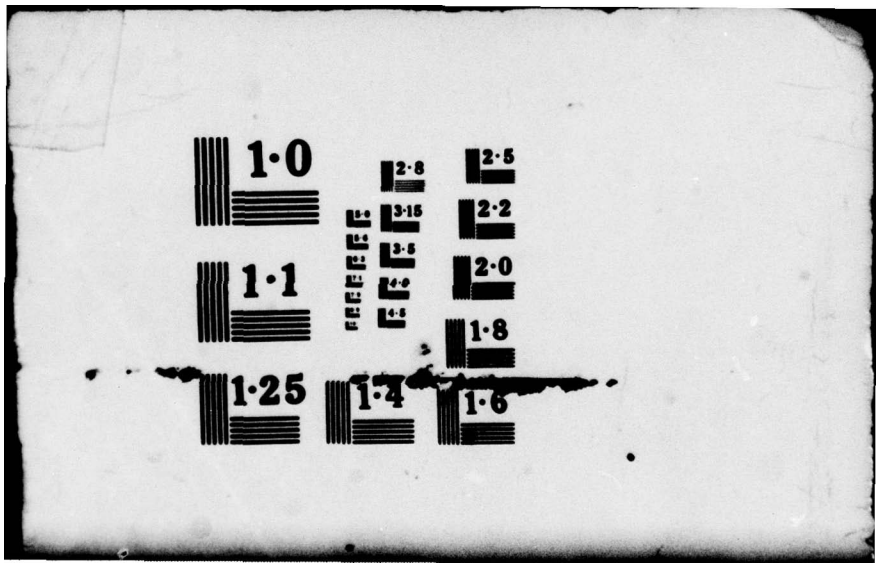
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THE EFFICACY OF ULTRASONIC CLEANSING

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ABSTRACT

Resin blocks containing simulated root canal spaces were compared with extracted teeth as models for the efficiency of endodontic debridement with hand instrumentation, ultrasonication and a combination of both techniques. Canal spaces were filled with radioisotope-laden gelatin and the loss of radioactivity measured after treatment. No significant differences in efficiency of debridement were observed in teeth prepared with hand instruments or ultrasonics alone as both techniques removed between 77 to 79 percent of the radioactivity. Ultrasonication following hand instrumentation was most efficient by removing 88 and 92 percent of the radioactivity in the teeth and blocks respectively.

Debridement of the root canal system is a critical phase of endodontic therapy.[1,2] It is directed toward the total removal of vital pulp tissue, necrotic debris and microorganisms from the treated tooth before obturation. As important as debridement is to successful endodontia, current techniques are inadequate in determining whether debridement has been achieved.

A clinical method for determining that the root canal system is adequately debrided has been the observation of clean white dentin shavings on the flutes of the reamer or file. However, if one keeps the system flooded with irrigation solution during instrumentation, the desired shavings become an unpredictable clinical paste which does not suggest the quality of total debridement.[3]

A partial list of *in vitro* evaluation standards has included use of radiopaque medium, numbers of microorganisms, radioisotope procedures, photography and light microscopy.[4-10] Scanning electron microscopic (SEM) studies have also evaluated different techniques of debridement and instrumentation.[11,12] McComb and Smith found that extracted, single-rooted teeth instrumented according to accepted clinical procedures produced a canal wall that was smeared and often packed with debris. This loosely attached layer was shown to contain not only dentin but also necrotic and viable tissue, remnants of odontoblastic processes, pulp tissue and bacteria. In addition, the cleansing properties of various irrigating solutions have also been studied.[13-18]

Weine et al. used clear resin blocks containing simulated pulp canal spaces and studied the effect of instrumentation on canal contours.[6,7]

These blocks were also recommended as educational tools for visualization of endodontic procedures. Although helpful for teaching purposes, visualization does not appear to be a satisfactory comparison when applied to debridement techniques. However, the use of resin blocks as models of pulp canal spaces along with a quantitative procedure using, for example, radioactively-labelled debris material, may be more useful in endodontic research.

The purpose of this study was to compare the debridement of simulated pulp canal spaces in resin blocks to that of natural teeth, both filled with radioactive-ladened gelatin and cleansed with hand instrumentation, a modified sonication probe and a combination of the two techniques.

METHODS & MATERIALS

30 single-rooted mandibular premolars and 30 resin blocks* containing simulated pulp canal spaces were selected. After the teeth were radiographed from the mesial to insure the absence of multiple canals, standard occlusal access openings were made and the pulp tissue removed with fine broaches. The teeth were placed in an ultrasonic unit% containing a solution of 5.25% sodium hypochlorite," activated for 15 minutes to remove the pulp remnants, hand washed in tap water and rinsed in distilled water for 1 hour in the ultrasonicator. The working length was determined visually by inserting a number 15 K-file# to the point of exit and subtracting 0.5 mm. The root apices were sealed with sticky wax and apical

*Richard W. Pecina & Associates, Inc., Waukegan, IL
%L and R Manufacturing Co., Kearny, NJ
"Chlorox Corp., Oakland, CA
#Kerr Dental Manufacturing Co., Romulus, MI

surfaces covered with boxing wax in order to reduce isotope contamination of the tooth surfaces. To prefill the dentinal tubules, hot gelatin[+] was injected into the teeth, allowed to cool for 30 seconds and removed from the main pulp canal space by absorption to paper points.[&]

The resin blocks were reduced in width to fit into counting tubes and the simulated periapical lesions eliminated by horizontal sectioning. In order to provide adequate space for manipulation, the "canals" were enlarged to a number 25 K-file to within 0.5 mm from the visualized apex. Sticky wax and boxing wax were then applied in a fashion similar with that of the teeth.

The teeth and resin blocks were then injected with hot gelatin containing ^{125}I-albumin, [ø] 3.48 μ Ci per ml, and allowed to cool to room temperature. The radioactivity of all specimens was determined with a gamma scintillation radiation counter.[@] The teeth and blocks were divided into three groups of ten specimens each and debrided by either: (1) hand instrumentation; (2) ultrasonication; or (3) hand instrumentation followed by ultrasonication.

In order to minimize clinical variables, the experimental procedures were performed by a single operator. All hand instrumentation utilized the serial preparation technique[3] with 2 ml of distilled water used between each file. The apices were prepared finishing with #30 K-files at the working lengths and #45 Hedstroem files at the coronal flares. In order to insure patency to the working lengths, #30 K-files were reintroduced.

+Knox Gelatin, Inc., Englewood Cliffs, NJ
&Johnson and Johnson, New Brunswick, NJ
øNew England Nuclear, Boston, MA
@Packard Instrument Co., Downer's Grove, IL

This was followed by the 5 ml irrigation in a 5 cc disposable syringe[++] and a 25 gauge injection needle.[@@] Intracanal drying was accomplished with five paper points.

Ultrasonication of the canals was performed with a Dentsply-Cavitron Ultrasonic Unit[**] fitted with a modified Cavitron insert. The smooth tapered stainless steel shank of a number 15 finger plugger,[øø] 25 mm in length, was spot-welded to the end of the insert. The probe was introduced to the working length of all specimens, activated and maintained at this measurement for 20 seconds. While still activated, the probe was gradually withdrawn through the coronal segments for 10 seconds. An effort was made to achieve maximum surface contact with the canal walls by employing lateral pressure and in a circular motion during preparation. The canals were then irrigated with 5 ml of distilled water and dried as in Group 1.

The combination of hand instrumentation and ultrasonication of Group 3 was a combination of the two previously described techniques. In order to have better control, only 2 ml instead of 5 ml of irrigation was used at the end of instrumentation. Upon completion of the ultrasonication phase, the specimens were irrigated with 5 ml of irrigant and dried.

Following debridement the wax covering was removed from the teeth and radioactivity determined in the teeth and resin blocks. The percent loss of radioactivity was calculated for each tooth and block, arranged for each group, and the significance of percent loss in radioactivity

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++Burron Medical Products, Bethlehem, PA
@@Becton, Dickenson and Co., Rutherford, NJ
**Dentsply International Inc., York, PA
øøUnion Broach Corp., Long Island City, NY

compared using the t-test.

RESULTS

Using the measurement of specific activity of the radioactive gelatin, the gel volumes of the resin blocks and teeth were calculated. The volume of gelatin within the blocks was 19.58±2.40 µl and in the prefilled teeth, 18.34±8.05 µl ($\bar{x}$ ± s.d.). In a pilot study with 40 non-prefilled teeth the volume of gelatin was 88.2 µl; furthermore, only a maximum of 24% of radioactivity was removed by using either hand instrumentation or hand instrumentation plus sonication.

Hand instrumentation and irrigation removed 78.9% of the radioactivity from the prefilled teeth in this study (Table 1, Group 1). Ultrasonication and irrigation reduced radioactivity by 76.6% (Table 1, Group 2). Both of these techniques were not significantly different in efficiency at the .01 level. Ultrasonication applied after completion of hand instrumentation and irrigation produced 88.2% removal of gel content which was significantly different from the other groups at the .01 level (Table 1, Gp 3).

In the resin blocks, hand instrumentation removed 83.07% of the radioactivity; ultrasonication removed 57.39%, and instrumentation followed by ultrasonication removed 92.24% (Table 1). The group 2 ultrasonication was significantly less efficient than the other two techniques at the .01 level. As in the teeth, hand instrumentation plus sonication was significantly more efficient than hand instrumentation alone in debriding the resin blocks at the .01 level. Scanning electron microscopy of the pulpal wall at mid-root region showed that a smeared

layer of dentin was present after hand instrumentation and ultrasonication. The dentinal tubules were obscured by a thin covering that was unaffected by the ultrasonic probe (Fig 1 and 2).

DISCUSSION

The physical action of ultrasonics is produced by cavitation of the solution.[19-21] This is the formation of submicroscopic voids, due to a shearing of the fluid medium, by the alternating, high frequency, movement of the tip. This movement is produced by a magnetostriction of the metal rod or "stack" in a fixed electromagnetic field, upon which is superimposed an alternating field. As successive waves pass along, the shearing effect develops an enlarged bubble of solution that grows until implosion occurs. The implosion effect creates a void that is filled with the surrounding solution under extreme hydrodynamic pressure which causes radiating shock waves. These waves can force a solution into all dimensions, however minute and inaccessible, of a particular system. The effect can create a most effective scrubbing and cleaning mechanism due to the irregular agitation.

The use of ultrasonics in endodontic procedures has received only limited study. Martin inoculated sterile prepared molars with test organisms and quantitated the bactericidal efficiency of endodontic irrigants when used with ultrasonics. The combined use of ultrasonics and irrigation improved the disinfection and cleansing of the root canal system.[19] Nossek evaluated the utility of ultrasonics in canal preparation using visual observation.[22] He reported that ultrasonic instrumentation alone was not adequate for fine, curved canals, or for

apical preparation. Hand instrumentation was recommended to finish the canal preparation. In the present experiment, ultrasonication used after complete hand instrumentation in both resin blocks and extracted teeth, produced an 88-92% debridement.

In the aforementioned pilot study, the importance of prefilling with a nonradioactive gelatin prior to collection of experimental data was emphasized. It was shown that failure to do so resulted in the retention of at least 76% of the subsequently injected radioactive material after debridement techniques were employed. It was concluded that the retained labeled debris mainly impacted in the dentinal tubules, beyond the reach of hand instruments or the sonicator probe.

This experiment compared the debridement of simulated pulp canal spaces in clear resin blocks to prefilled teeth, both subsequently filled with radioactive gelatin debris. As an experimental model, the use of extracted teeth presented some difficulties for quantification; namely, the irregular main pulp canal spaces and dentinal tubules. On the other hand, resin blocks added an uniformity of shape and volume to the canal space. This was evident in the smaller standard deviation in the canal volume of the blocks as measured from the specific activity of the gelatin content. These blocks were evaluated in the hope of offering an inexpensive, accurate, and rapid method of objectivity in analyzing pulp canal space debridement and perhaps relating it to the already demonstrated versatility of the resin in visualizing debridement. The use of resin block simulation offered an additional advantage of eliminating intratubule impaction during quantitative evaluation of debridement. Regardless of the model used,

10-30% of the debris still remained in the blocks and teeth.

Throughout this experiment, attempts were made to duplicate clinical conditions as much as possible; consequently, conventional materials and techniques were used. When appraising the combined technique, it was decided to measure ultrasonication after instrumentation was completed rather than supplementing each instrument alternatively with the sonicator probe. This seemed to be the more relevant clinical method based on the reduction of time. The canals were irrigated using not only clinical materials, but of probably equal importance, similar clinically-determined irrigation pressures. The canals were dried with sterile paper points using clinical parameters.

The most effective debridement occurred when ultrasonication was used after completion of hand instrumentation in both teeth and resin blocks. It was theorized that ultrasonication loosened debris from the canal walls, allowing more complete removal with the subsequent 5 ml of irrigation.

Ultrasonics was a useful adjunct to endodontic debridement both in time and efficiency. Assuming a 15 min. canal preparation time, clinically the 30 sec. or 3.3% additional time for application of the ultrasonic probe produced a 10% increase in debridement of the canal contents. Ultrasonication reduced by one-half the residual debris in the root canal space that was left by hand instrumentation, both in the teeth and the resin blocks. The use of hand instruments, however, is still recommended for enlarging and shaping the canal for obturation. Our results indicate that ultrasonication is a valuable aid in the conventional technique if used in the proper sequence with hand instruments.

SUMMARY

Resin blocks containing simulated root canal spaces were compared with extracted teeth as models for the efficiency of endodontic debridement with hand instrumentation, ultrasonication and a combination of both techniques. Canal spaces were filled with radioisotope-laden gelatin and the loss of radioactivity measured after treatment. No significant differences in efficiency of debridement were observed in teeth prepared with hand instruments or ultrasonics alone as both techniques removed between 77 to 79 percent of the radioactivity. Ultrasonication following hand instrumentation was most efficient, removing 88 percent of the radioactivity. The results were similar for resin blocks except that ultrasonic debridement used alone was not as effective as hand instrumentation. Scanning microscopy revealed the presence of a smeared layer of dentin, covering the dentinal tubule orifices, both after hand instrumentation alone or in combination with ultrasonication. Ultrasonication is not suggested as an alternate to conventional hand instrumentation, but is a significant aid in increasing the efficiency of endodontic debridement.

MILITARY DISCLAIMER

Commercial materials and equipment are identified in this report to specify the investigation procedures. Such identification does not imply recommendation or endorsement, or that the materials and equipment are necessarily the best available for the purpose. Furthermore, the opinions expressed herein are those of the authors and are not to be construed as those of the Army Medical Department.

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FIG 1 Scanning electron micrograph of the pulpal surface of mid-root dentin after deproteinization with sodium hypochlorite and before filling with gelatin. The surface contains numerous patent tubules. Original magnification, 5000 times.

FIG 2 Scanning electron micrograph of the same region of the pulpal wall after hand instrumentation and ultrasonication. The tubules are obscured with a smeared layer of dentin. Original magnification, 5000 times.

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TABLE 1

PERCENT LOSS IN RADIOACTIVITY

	DEBRIDEMENT TECHNIQUE	TEETH	BLOCKS
Group 1	Hand instrumentation	78.9%	83.07%
Group 2	Ultrasonication	76.6%	57.39%
Group 3	Hand instrumentation plus ultrasonication	88.2%	92.24%